

An Attempt to Analyse the Driving Forces of Land Use Changes of a Tropical River Basin: A Case Study of the Muhuri River, Tripura, North-East India

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ABSTRACT

The present study illustrates the spatio-temporal change of land use and land cover of the Muhuri River basin using multispectral imagery under GIS environment. Satellite imagery is the good representation of spatiotemporal change of LULC of the study area. The remote sensing data, derived from Land sat imagery acquired by Earth Explorer for three different years i.e., 1975, 1995 and 2016, and processed using different enhancement techniques. For change detection of LULC supervised classification method has been adopted using maximum likelihood technique in Arc GIS 10.1. The LULC of the study area has been categorised into six types like open forest, dense forest, settlement, barren land, cultivated land and water body. The classification accuracy is assessed by estimating the Overall Accuracy, Producer's Accuracy and User's Accuracy. The overall accuracy of all the maps ranges between 87- 91%. The study of land use change in four decades (1975-2016) shows that settled area and agricultural area of the basin have been increased by 180.95% and 128.36% respectively while, on the other hand, the area under open forest and dense forest have been decreased by 69.04% and 92.56% respectively. The study also reveals that high population pressure and traditional jhoom cultivation trigger the conversion of the forest land into settled area, agricultural land and barren land.

Keyword: Driving force; Land use/land cover; Change detection; Forest; Plantation; Population pressure.

Mathematics Subject Classification: 62H35

Computing Classification System: Q15, Q23, Q57

1. INTRODUCTION

Land use/land cover becomes a most common and fundamental word in this modern technological world which describes terrestrial environment in association with natural processes and human activities (Bendor et al. 2005; Mendoza et al. 2011). Land use indicates the man's activities and varied uses which are acting on overland and land cover is the natural covers of the surface of the earth. Nowadays land use/land cover change analysis has been identified as a key factor for environmental modifications and due to this it has been emerged as a most important research question worldwide (Xiao et al. 2006). There is an increasing need for standardized land use and

land cover information, especially in critical areas of environmental concern like urban extension and forest clearing in the developing countries as they endeavour to catch up with the current development of economic globalization (Sylla et al. 2012). According to the Lupo et al. (2001), land use/land cover (LULC) change affects biodiversity, hydrological cycle, soil erosion and sustainability of the natural environment. The surface of the earth is continuously changing due to the LULC change and this change accelerated by anthropogenic activities and natural processes (Reid et al. 2000; Sahana et al. 2016). In perspective of the river basin analysis of the spatial and temporal change of the LULC is considered as diagnostic methods to understand the problem persisting in a river basin (Mayaja and Srinavasa 2016). Considering the river basin, the spatio-temporal changes of the LULC created a direct influence on the hydrological realm of the river basin. Generally, due to the deforestation and conversion of the wet lands into build up area directly affects on the natural water flow regimes of the basin as well as characteristics which influence the flood and drought (Petchprayoon 2010). Therefore, preparation of the LULC change map and its related study provides crucial information about the vulnerability assessment, sustainable development and proper management of the river basin (Ali and Tesgaya 2010; Soma and Kubota 2017).

The study region is located partially in the hilly terrain which is a part of the southern district of Tripura (Figure 1). The Muhuri River basin has 'tilla-lunga' topography, tremendous encroachment on forest resulting deforestation and a significant fluctuation of climate; all contribute to a significant environmental change of the study area. Above all, the consequences of escalated population and anthropogenic activities have resulted to land cover change and thus have degraded the natural hydrological condition of the river. Mitigation and conservation practices are required to lessen such changes of forest cover by allocating the susceptible areas by highlighting them through mapping, monitoring and prioritizing. Therefore, the present study area has been selected to assess the LULC changes during different time periods. The main objective of this research is to evaluate the Land use/Land cover (LULC) change and monitor the driven forces to such disturbances present in the Muhuri River basin from 1975 to 2016 periods. Recent studies related to land use/land cover disturbance and human interferences shows that such external activities have adverse effects on natural areas and wetlands.

2. DATABASE AND METHODS

Evaluation of the land use/land cover change caused by man–environment interaction process, by using RS and GIS technology, is a most common method in modern times (Kayet, 2006; samanta 2016; Kangrang et al. 2017; Achmad et al. 2018). For LULC change analysis multi-temporal cloud free Multi-spectral scanner (MSS) data of 1975, Thematic Mapper (TM) data of 1995 and Operational Land Imager (OLI) 2016 were obtained from Land sat org. and USGS (United States Geological Survey) archives. Whereas, FSI data on forest cover and Google earth imagery have been used for classification accuracy and field study was carried out for ground truth verification using GPS. The study of LULC change detection and its evaluation was performed adopting a series of steps and processes including data acquisition, image sub-setting, data pre-processing, supervised classification and Post Classification Comparison. Landsat images for the dry season were utilised

and as part of radiometric corrections haze reduction, noise reduction and histogram equalisation performed for the entire satellite image. The radiometric correction is a common method adopting to reduce inconsistencies in the satellite images which are inherent in the images because of differences in acquisition conditions including variation in sun zenith angles (Yang and Lo 2000; Hazarika et al. 2015). The projection transformation was carried out and assigned the UTM WGS-84, 46N projection, in order to make the data compatible with each other. In order to remove the error during overlaying and change detection analysis of three satellite images, image to image registration was performed by taking the image of 1975 as base image.

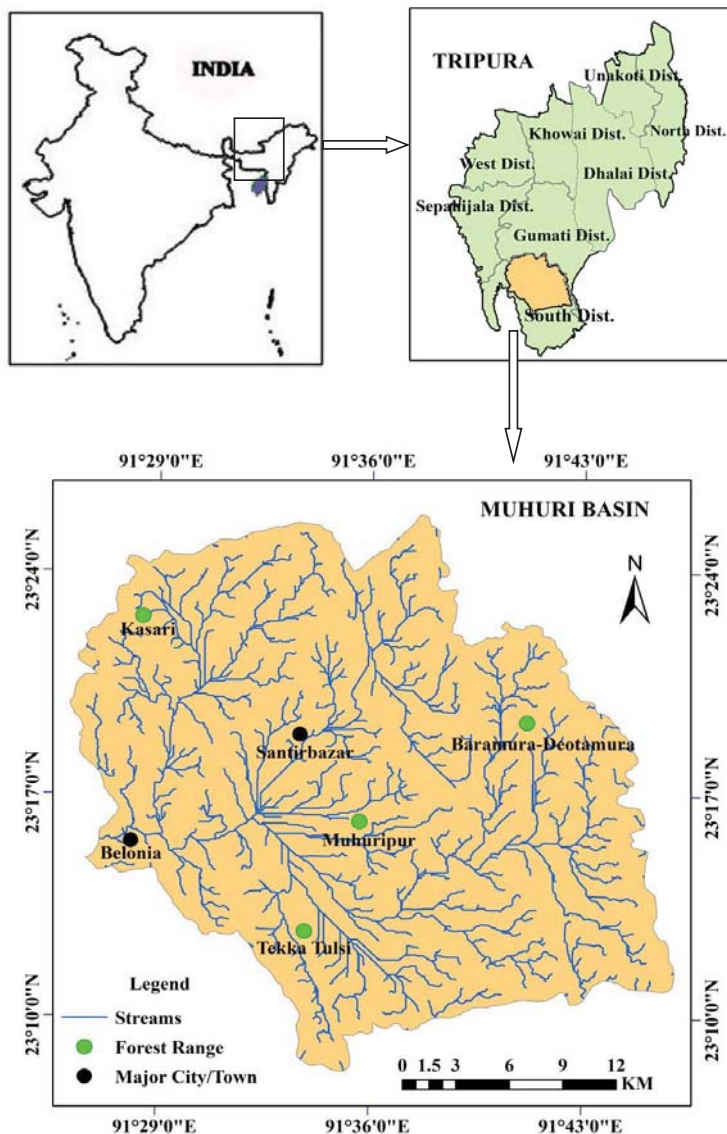


Figure 1. Location map of the study area.

Table 1. Classification proposal used for the study

Land use/Land cover classes	Description
Settlement	Rural and urban built up area including home stead area.
Water body	Open water features such as natural lake, pond, river, reservoir etc.
Degraded forest	Area covered by scrubs and bushes
Cultivated land	Areas under cultivation where agricultural crops are harvested
Barren land	Areas without vegetation cover, exposed areas etc.
Plantation	a type of monoculture activity practiced in hill/tilla and slopes
Open forest	Sparsely distributed forest area where human interference is more
Dense forest	Densely distributed forest area where human interference is less.

Supervised and unsupervised are the two categories of image classification used for LULC change analysis. Supervised classification approach involves the selection of training areas of the specific pixels on the image which statistically characterize LULC categories; on the other hand, unsupervised classification approach attempts to identify spectrally homogenous groups within the image that are later assigned to LULC categories (Richards and Jia 2006). As supervised classification is likely to provide more accurate classification result than unsupervised classification (Butt et al. 2012), therefore, in this research work supervised classification was used on the basis of training sites using maximum likelihood technique. Maximum likelihood technique is considered to be one of the most accurate classifiers since it is based on statistical parameters (Shalaby and Tateishi 2007). Eight LULC classes were identified in this study to analyse the work (Table 1). In order to compare the training signature histogram tool was used. Transformed divergence index was used to check the separability of the selected signatures.

The term accuracy is used typically to express the degree of 'correctness' of a map or classification of thematic map from remotely sensed data (Foody 2002). Accuracy of the classified maps were assessed with the help of reference points using the field data and high resolution Google earth imagery at particular classification-wise. This assessment was generated by using a statistical technique. Confusion matrix is widely used for this accuracy assessment. This matrix was calculated applying producer's accuracy, user's accuracy and omission and commission percentage. All the accuracies and Kappa coefficient were calculated using this confusion matrix. Overall accuracy was calculated by summing up the number of pixels classified correctly and dividing them by the total number of pixels. Kappa Co-efficient mainly determines the degree of agreement or correctness among the classified map and the reference data (Congalton 1991; Rosenfield and Fitzpatrick 1986).

Change detection analysis is a comprehensive work of GIS technology. It is mainly applied for comparing the LULC change map and evaluating the conversion/change from year to year. For such work, PCC (Post Classification Comparison) method was used comprehensively. In order to obtain LULC change map, each of the particular imagery was classified independently, then this resulting map overlaid and compared on pixel by pixel basis using the PCC method (Bhatta 2010; Debnath et al. 2017; Debnath et al. 2017). Applying this pixel-by-pixel overlaying technique 'From-To' change

maps were obtained. This is a simple statistical technique where, using two change maps, conversion of Land use/Land cover can easily be identified.

3. RESULTS AND DISCUSSION

3.1 Land use/land covers change analysis of the basin

LULC classification has been determined using the supervised classification technique for the year 1975, 1995 and 2016. The 1975 map classified into seven LULC types: settlement, water body, degraded forest, cultivated land, barren land, open forest and dense forest (Figure 2).

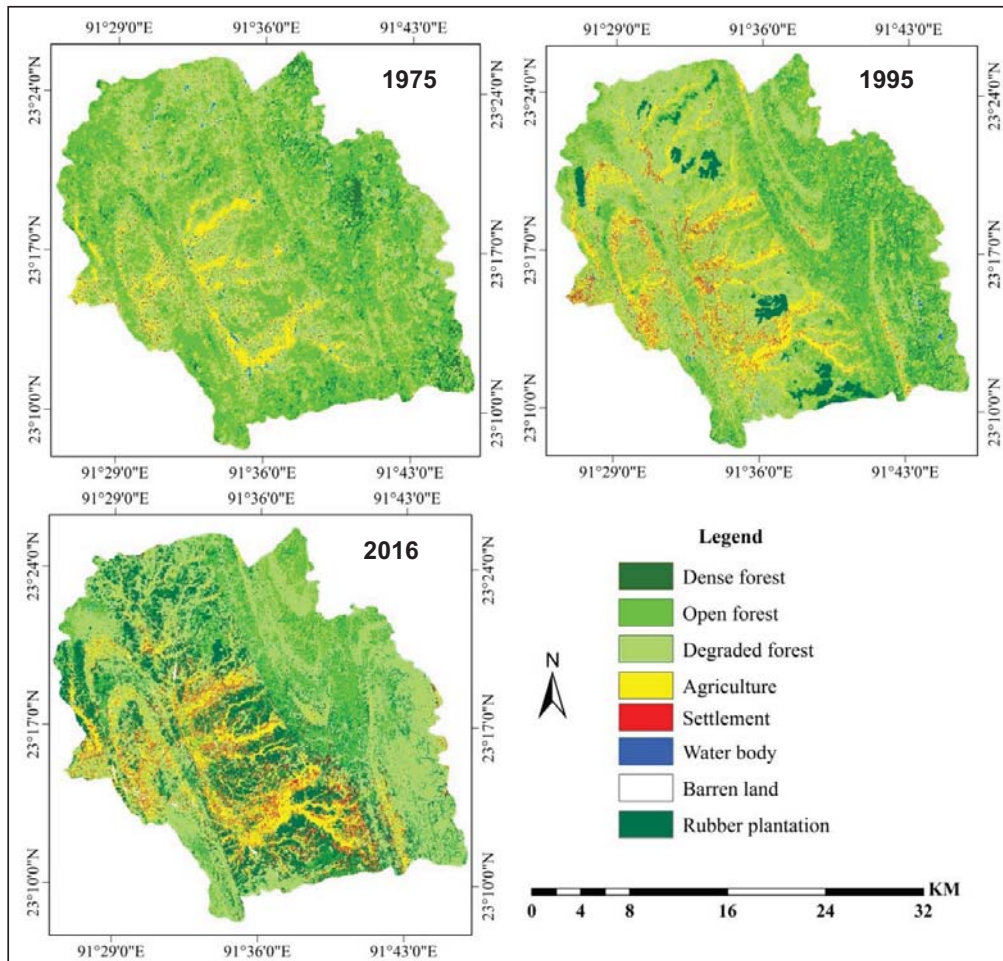


Figure 2. LULC classification map of 1975, 1995 and 2016.

On the other hand, the 1995 and 2016 maps have been classified into eight types as plantation became one of the major land use classes. The classification results (Table 2) reveal that the highest percentage of land (42.78 per cent) was under open forest cover in 1975 which gradually decreased to 24.99 per cent and alarmingly to 13.24 per cent in 1995 and 2016 respectively. On the other hand,

area under dense forest became 6.30 per cent to 0.47 per cent within the study period 1975 to 2016. Area under water body did not show any significant change during last 40 years. Areas under degraded forest and settlement have been increased significantly. Moreover, within this study period 1975 to 2016 agricultural land has been increased only 5.01 per cent to 11.44 per cent whereas newly introduced rubber plantation occupied 0 per cent to 20.64 per cent study area interestingly.

Table 2. LULC Classification results for the year 1975, 1995 and 2016

LULC classes	1975		1995		2016		Relative change of area (%)		
	Area (sq km)	Area (%)	Area (sq km)	Area (%)	Area (sq km)	Area (%)	1975-1995	1995-2016	1975-2016
Settlement	16.64	2.37	34.39	4.9	46.75	6.66	106.67	35.94	180.95
Water body	14.64	2.09	12.65	1.8	10.15	1.45	-3.73	-19.76	-30.67
Degraded forest	261.43	37.26	311.9	44.45	312.3	44.50	19.31	0.13	19.46
Cultivated land	35.16	5.01	75.71	10.79	80.29	11.44	115.33	6.05	128.36
Barren land	0.42	0.06	0.15	0.02	2.23	0.32	-64.29	1386.67	430.95
Plantation	Absent	Absent	32.43	4.62	144.8	20.64	-	346.50	-
Open forest	300.2	42.78	175.36	24.99	92.93	13.24	-41.59	-47.01	-69.04
Dense forest	44.2	6.30	42.53	6.06	3.29	0.47	-3.79	-92.26	-92.56
Total	701.72	100	701.72	100	701.72	100			

For assessing the accuracy of three years' map producer's accuracy, user's accuracy, omission, commission, overall accuracy and Kappa co-efficient has been calculated. The classified images show overall accuracy of 87, 88 and 91 per cent for the Muhuri River basin in 1975, 1995 and 2016 with kappa co-efficient of 86, 87 and 89 per cent respectively (Table 3). Over the map of 1975, dense forest, open forest, cultivated land and water body have been classified more accurately whereas settlement and degraded forest area have been showing confused. In case of the 1995 map, plantation, open forest, dense forest and water body have been classified accurately whereas settlement, degraded forest and cultivated land displayed some confusion. On the other hand, in case of the 2016 map, plantation and open forest areas have been showing confused, whereas, the remaining classes have been classified accurately. Overall the accuracy percentage and Kappa statistics results suggest that the result is reliable and acceptable.

Table 3. Confusion matrix of the classified LULC maps

LULC 1975	SM	W B	D GF	C L	B L	OF	D F	Row Total	PA %	UA %	CM %	OM %	
SM	21	0	0	0	0	0	0	21	67.74	100	0	32.23	
W B	0	49	0	0	0	0	0	49	98	100	0	2	
D GF	0	0	22	0	0	0	0	22	45.83	100	0	54.17	
C L	0	1	0	59	4	0	0	64	98.33	92.19	23.81	1.67	
B L	0	0	0	1	18	0	0	19	81.82	94.74	4.76	18.18	
OF	0	0	0	0	0	61	1	62	100	98.39	4.76	0	
DF	10	0	26	0	0	0	70	106	98.59	66.04	171.43	1.41	
Total	31	50	48	60	22	61	71	343					
Overall accuracy for the year 1975=87%; Kappa co-efficient=86%													
LULC 1995	SM	W B	D GF	C L	B L	PLN	O F	D F	Row Total	PA %	UA %	CM %	OM %
SM	25	8	0	1	0	0	0	0	34	75.76	73.53	26.47	24.24
W B	3	37	0	0	0	0	0	0	40	74	92.5	7.5	26
DGF	3	3	51	15	0	0	1	0	73	85	69.86	30.14	15
C L	2	2	3	73	7	0	0	0	87	78.49	83.91	16.09	21.50
B L	0	0	0	0	13	0	0	0	13	65	100	0	35
PLN	0	0	1	0	0	95	0	1	97	97.94	97.94	2.06	2.06
O F	0	0	5	4	0	2	92	2	105	98.92	87.62	12.38	1.07
D F	0	0	0	0	0	0	0	79	79	96.34	100	0	3.66
Total	33	50	60	93	20	97	93	82	528				
Overall accuracy for the year 1995=88%; Kappa coefficient=87%													
LULC 2016	SM	W B	DG F	C L	B L	PLN	O F	D F	Row Total	PA %	UA %	CM %	OM %
SM	36	0	0	3	0	1	0	0	40	90	90	10	10
W B	0	60	0	0	0	0	0	0	60	100	100	0	0
DG F	0	0	80	0	0	0	0	0	80	100	100	0	0
C L	4	0	0	77	0	0	0	0	81	96.25	95.06	0	3.75
B L	0	0	0	0	19	0	0	0	19	100	100	0	0
PLN	0	0	0	0	0	79	27	1	107	87.78	73.83	26.17	12.22
O F	0	0	0	0	0	10	53	0	63	66.25	84.13	15.87	33.75
D F	0	0	0	0	0	0	0	69	69	98.57	100	0	1.43
Total	40	60	80	80	19	90	80	70	519				
Overall accuracy for the year 2016= 91%; Kappa Accuracy=89%													

DF- Dense forest; OF- Open forest; DGF- Degraded forest; CL- Cultivated land; PLN- Plantation; SM- Settlement; WB- Water body; BL- Barren land; PA- Producers Accuracy; UA- Users Accuracy; CM- Commission; OM- Omission.

The land use/ land cover study has provided a considerable changing data of different periods that have been caused by human intervention as well as natural factors. Figure. 3 and 4 display the change area of the LULC map between 1975 to 1995 and 1995 to 2016. The classification results suggest that in 20 years period (1975 to 1995) the areas under settlement, degraded forest and cultivated land have been increased by 106.67 per cent, 19.31 per cent and 115.33 per cent respectively. On the other hand, the areas under water body and barren land have been changed at

the rate of -3.73 per cent and -64.29 per cent respectively. The percentages of dense forest and open forest have decreased at the rate of -3.79 per cent and -41.59 per cent respectively.

Table 4. 'From-to' changes in LULC from 1975-1995

From	To	Area (km ²)	Area (%)
Water body	Settlement	2.35	49.68
Water body	Water body (unchanged)	0.57	12.05
Water body	Cultivated land	1.81	38.27
Degraded forest	Degraded forest	7.7	63.74
Degraded forest	Cultivated land	4.38	36.26
Cultivated land	Cultivated land (unchanged)	24.76	71.21
Cultivated land	Water body	0.48	1.38
Cultivated land	Degraded forest	9.53	27.41
Open forest	Plantation	17.15	17.93
Open forest	Dense forest	7.74	8.09
Open forest	Open forest (unchanged)	59.08	61.75
Open forest	Settlement	1.12	1.17
Open forest	Degraded forest	9.97	10.42
Open forest	Cultivated land	0.61	0.64
Dense forest	Dense forest (unchanged)	54.97	11.65
Dense forest	Open forest	92.97	19.71
Dense forest	Degraded forest	151.49	32.12
Dense forest	Plantation	114.73	24.33
Dense forest	Cultivated land	18.39	3.90
Dense forest	Settlement	39.08	8.27

Assessment of the next 20 years period (1995 to 2016) shows that the areas under settlement, cultivated land, degraded forest and plantation have increased by 35.94, 6.05, 0.13 and 346.50 per cent respectively whereas, area under water body, open forest and dense forest decreased by -19.76, -47.01 and -92.26 per cent respectively. A Significant loss in areas under dense forest and open forest noticed from the overall analysis (1975 to 2016) which have mainly converted into plantation. In order to signify the conversion of LULC of the study area, two change maps have been obtained by overlaying of the map of 1975, 1995 and 2016. The change maps have been displayed as 'From-to' map. Both the change maps (Figure. 3 and 4) give information about the changed and unchanged areas with colour.

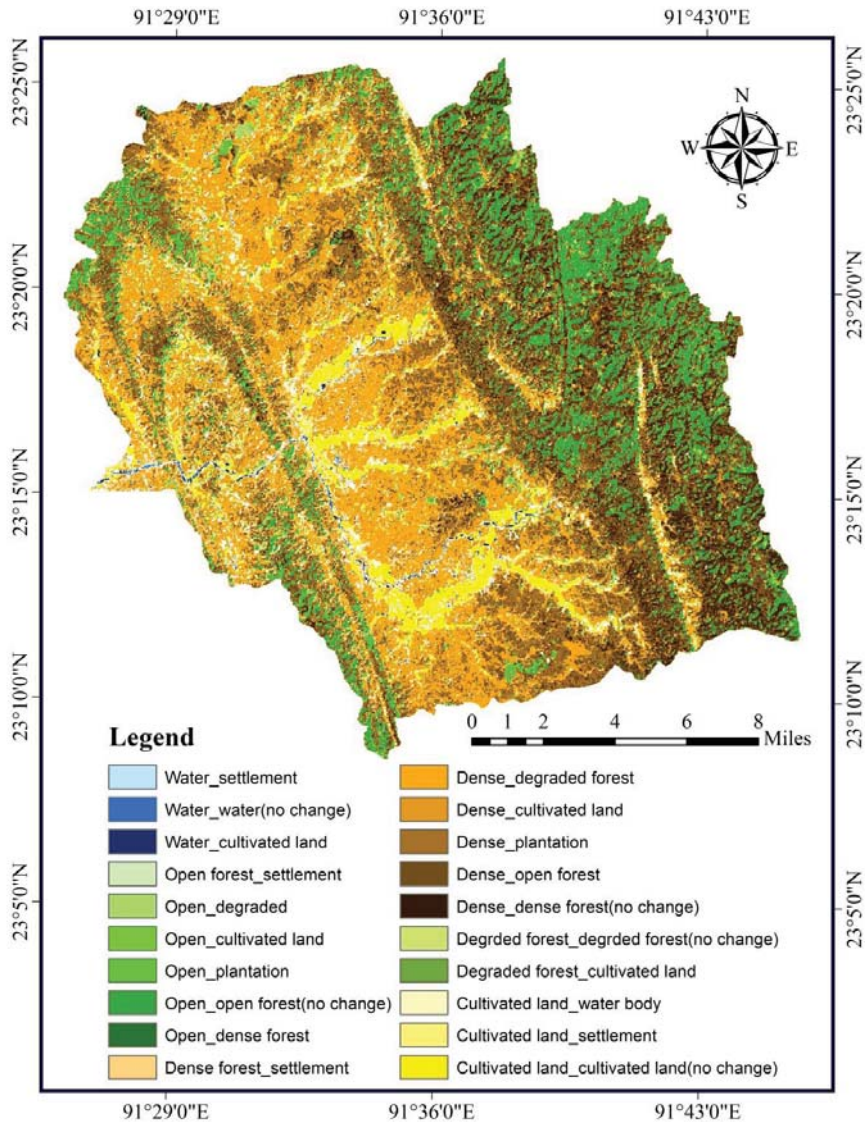


Figure 3. LULC change map displays from-to class changes from 1975-1995.

The 'from-to' map from 1975-1995 (Figure. 3) analysed the significant conversion. The detailed summary of Table 4 shows that dense forest area largely converted into settled area (8.27 per cent), degraded forest (32.12 per cent), plantation (24.33 per cent) and open forest (19.71 per cent) whereas the open forest area has been replaced by settlement (1.17 per cent), degraded forest (10.09 per cent), plantation (17.93 per cent), dense forest (8.09 per cent) and 61.75 per cent remain unchanged. The Cultivated land has been occupied by water body (1.38 per cent), degraded forest (27.41 per cent) and 72.21 per cent remain unchanged. The area under degraded forest mainly replaced by cultivated land (36.36 per cent) whereas 63.74 per cent remain unchanged. On the other hand, 49.68 and 38.27 per cent water body have been converted into settlement and cultivated land

respectively and 12.05 per cent remain unchanged. The same kind of modifications is also present in the 1995 to 2016 change map (Figure 4).

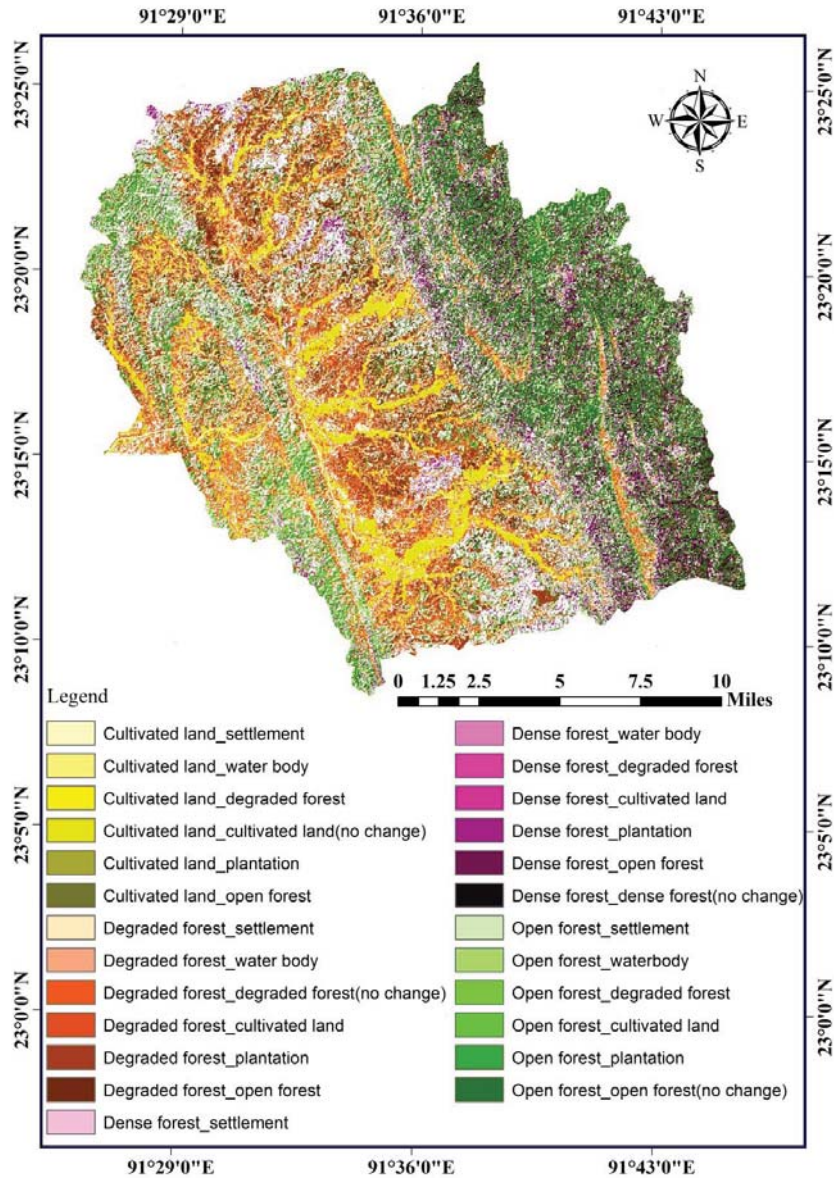


Figure 4. LULC change map displays 'from-to' class changes from 1995-2016.

The Table 5 displays that dense forest and open forest have mostly converted into other elements of land use/land cover. Dense forest has been decreased in surface area and converted into settlements (2.27 per cent), water body (0.38 per cent), degraded forest (1.33 per cent), plantation (24.73 per cent), open forest (51.67 per cent) and agriculture (0.12 per cent). On the other hand, open forest has been replaced by settlement (4.05 per cent), water body (0.06 per cent), degraded forest (6.28 per

cent), plantation (32.66 per cent) and dense forest (0.12 per cent). The replacement of agricultural land into other elements also significantly follow the trend as settlement 15.23 per cent, degraded forest 14.21 per cent, plantation 5.97 per cent, and open forest 1.59 per cent and barren land 0.13 per cent. The changed area of water body to other land use/land cover elements is as follows: settlements 13.45 per cent, degraded forest 8.45 per cent, agricultural land 16.45 per cent, and plantation 16.37 per cent. Whereas degraded forest mainly alter into settlement 17.40 per cent, water body 0.79 per cent, plantation 38.16 per cent and open forest 9.16 per cent respectively. The other land use/land cover elements such as settlements, barren land and plantation have slightly conversed into other land use/land cover elements.

Table 5. 'From-to' changes in LULC from 1995-2016

From	To	Area (km²)	Area (%)
Water body	Settlement	0.23	13.45
Water body	Water body (unchanged)	0.74	43.27
Water body	Degraded forest	0.23	8.45
Water body	Cultivated land	0.23	16.45
Water body	Plantation	0.28	16.37
Degraded forest	Settlements	31.75	17.40
Degraded forest	Water body	1.45	0.79
Degraded forest	Degraded forest (unchanged)	44.53	24.41
Degraded forest	Agriculture	18.2	9.98
Degraded forest	Barren land	0.07	0.04
Degraded forest	Plantation	69.62	38.16
Degraded forest	Open forest	16.71	9.16
Degraded forest	Dense forest	0.11	0.06
Cultivated land	Open forest	0.83	1.59
Cultivated land	Degraded forest	7.4	14.21
Cultivated land	Plantation	3.11	5.97
Cultivated land	Settlement	7.93	15.23
Cultivated land	Cultivated land (unchanged)	32.14	61.72
Cultivated land	Water body	0.59	1.13
Cultivated land	Barren land	0.07	0.13
Open forest	Settlements	5.9	4.06
Open forest	Water body	0.09	0.06
Open forest	Degraded forest	9.14	6.28
Open forest	Cultivated land	0.64	0.44
Open forest	Barren land	0.02	0.01
Open forest	Plantation	47.51	32.66
Open forest	Open forest (unchanged)	81.98	56.36
Open forest	Dense forest	0.17	0.17
Dense forest	Settlement	1.3	2.27
Dense forest	Water body	0.22	0.38
Dense forest	Degraded forest	0.76	1.33
Dense forest	Agriculture	0.07	0.12
Dense forest	Plantation	14.17	24.73
Dense forest	Open forest	29.61	51.67

3.2 Driving forces of Land use/Land cover changes of the basin

The above study of changes in LULC elements during last 41 years period indicate the large scale intervention of various anthropogenic factors. The authors, in this paper, have tried to explore the reasons behind such significant decrease in dense forest, degraded forest, water body and increase in open forest, settled area, cultivated land, plantation etc. (Table 2) during the study periods.

3.2.1 Population growth: Extensive population growth in the study area is mostly responsible for such changes. Here the tribal are the main inhabitants whereas most of the Bengali population are the immigrants. Figure 4.8 displays that during 1971 population were quite less compared to the other study year but later the magnitude of population reached a highest peak. Population has been escalated from 88,000 to almost 2,00,000 (almost 150 per cent) with tremendous effect on the forests.

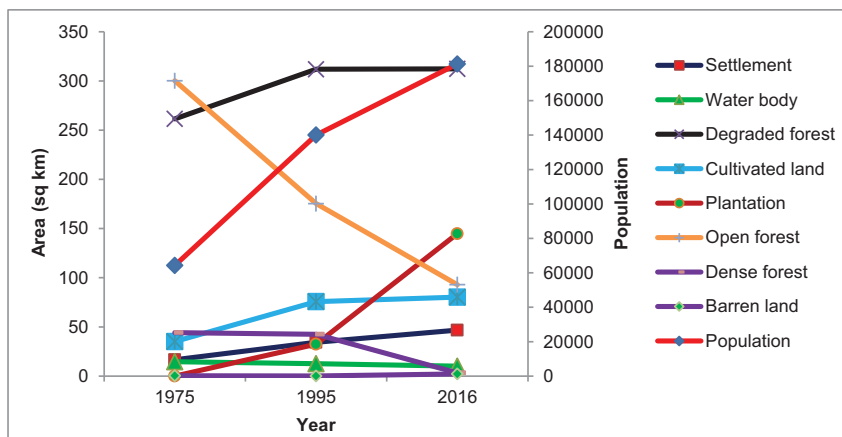


Figure 5. Effects of rising population force upon LULC changes.

3.2.2 Increasing settlement: With the increasing population the demand of the construction of houses/settlements increased extensively in the study area which significantly started to occupy forest lands, water bodies and agricultural lands (Figure 6).

3.2.3 Increasing cultivated land: The study area is mostly covered by hilly area and undulating 'tilla-lunga' topography and therefore, cultivated land is less in terms of the total area during all the study periods i.e. 5.01 per cent in 1975 and 11.44 per cent in 2016. So with ever growing population cultivated land has been increased at a very negligible rate. However this increase has taken place at the cost of the natural forests and the water bodies (Figure 7).

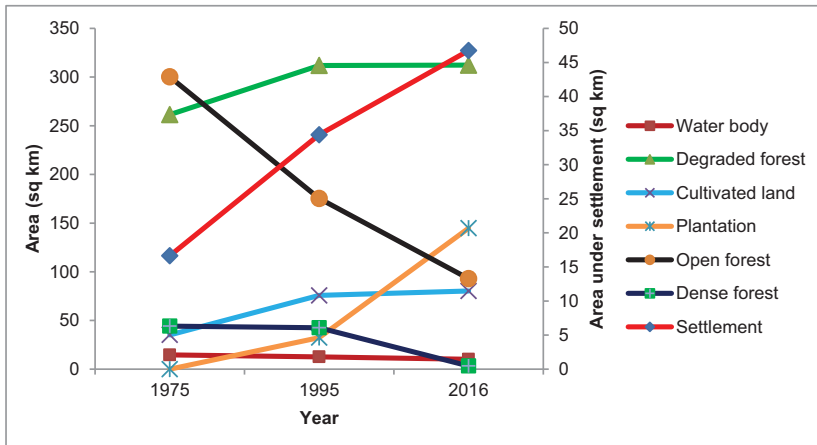


Figure 6. Changes of LULC owing to growing settlement.

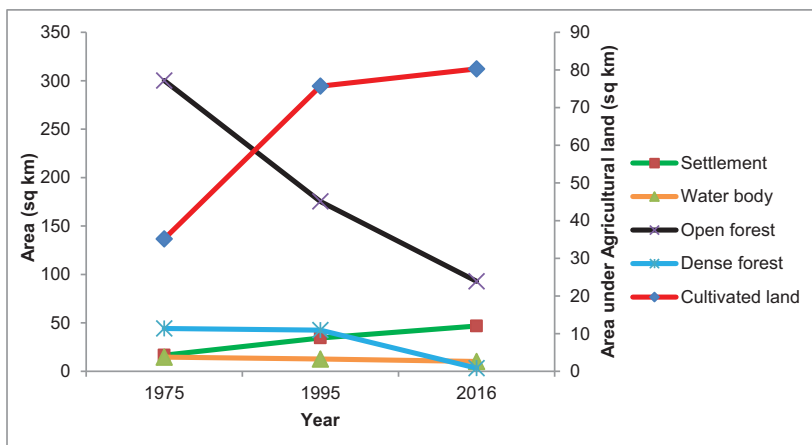


Figure 7. Effect of increasing agricultural activities on other LULC.

3.2.4 Plantation: Plantation particularly rubber plantation has tremendously occupied the forest lands. In 1975 plantation was totally absent (Figure 8) in the study area but after 1982, when scientifically rubber plantation was accepted for Tripura state, people of this economically most backward area started to replace the forest lands (degraded forest, open forest, dense forest) into rubber plantations. Therefore this plantation which was absent in 1975 has contributed 24.91 per cent in the year 2016. Recent field visit shows that the people have planted rubber in the cultivated land also (Figure 9).

3.2.5 Jhoom or Shifting Cultivation: Shifting cultivation is the inherent type of cultivation in the hilly terrain of Tripura and predominant in the upper catchment of the Muhuri River basin (Figure 10). This cultivation mainly practised by indigenous tribal people of the study area and encroached the natural forest cover using the slash and burn technique (Debnath et al., 2017). The increasing refugee influx from the neighbour country Bangladesh after post independence period, were harassed and evicted the local tribal people from their forest land. As a result, it became difficult for them to survive over

their own land and thus forced to shift towards the upper catchment area. In addition, the traditional jhumias (the fallow period of a particular jhoom plot was for 20-25 years) were bound to accept the non-traditional jhum activity (the fallow period of a particular jhoom plot becomes three to four years only) due to decline of forest land (Gupta 2000). This overwhelming non-traditional jhumming have reduced the quantity of healthy vegetated area and lead to increase the degraded forest as there have been complete arrests of secondary succession and favoured the weed infestation in the hilly area.

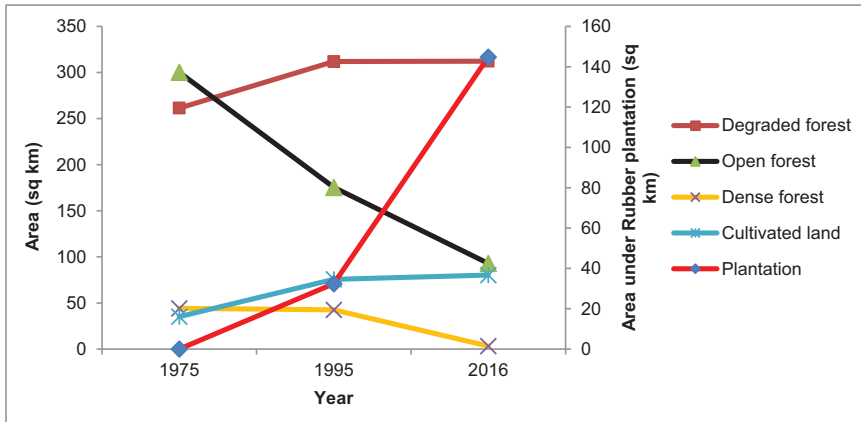


Figure 8. Increasing demand of rubber plantation leads to the change in LULC of the study area.



Figure 9. Rubber plantations in the plain land and tilla land of the study area.

3.2.6 Timber and fuel wood collection: The forests are the source of timber and fuel wood whose collection and sale become main occupation of the local people. Besides, collection of timber from forests, either unscientifically or unconsciously, is also a major factor of LC change. Moreover, with increasing demand for housing people vigorously collect timber from the forests. In this way, the conversion of open forest into degraded forest and dense forest into open forest has taken place.

3.2.7 Collection of raw material: Cottage industry can be recognised as one and the only one industry in the study area. This industry is fully associated with the forest resources, mainly bamboo.

Usually people used to collect bamboo for this purpose freely from the natural forest and this uncontrolled collection has lead to degrade the forest cover.



Figure 10. Shifting cultivation in hilly area of the study area.

3.2.8 Urbanization: Urbanisation plays an important role on Land use/Land cover (LULC) change in the study area. According to the Ahmad et al. (2017), urbanization is a fast land use process that produces different spatial patterns depending upon the large urban cities across the landscape. The two urbanised areas namely, Belonia and Santirbazar are characterized by heterogeneous LULC change and have impact on the Muhuri River which flows through both the areas. The rapid expansion of urban areas has resulted to modify a particular land use to the other type. For instance, large portion of agricultural and barren lands have been converted into either human settlements or administrative buildings. The increasing population, as well as the growing built up areas have directly or indirectly brought some changes to the river basin for different developmental purposes and for various factors such as drilling sand from river, urban disposal etc. Although, the total urbanised area is 19.84 km^2 which occupy only 3 per cent of the study area, but for the growing economy and for enjoying the better socio-cultural environment, people are moving towards the urban areas. Therefore, the old urban areas are expanding and the government is introducing new urban areas. The two urbanised areas i.e., **Santirbazar and Belonia** are situated in the study area and interestingly both have built up along the river bank. As a result, large open area along both sides of the river is occupied by the buildings.

4. CONCLUSION

The research has proved that the growing anthropogenic activities have generated pressure on the forest cover and consequently changed the land use/land cover of the Muhuri River basin. During this 39 years' study from 1975 to 2016, the dense forests and open forests have sharply declined by 92.56 per cent and 69.04 per cent respectively whereas degraded forest has increased by 19.46 per cent. High encroachment of anthropogenic activities, conversion of dense forest and open forest, mainly to plantation, degraded forest and settlement which have created a significant change of the LULC of the study area. About 128 percent population has been increased in the study area during 1971 to 2011 periods (Census Reports of 1971-2011) mainly due to the migration of Bengali people

from Bangladesh. Demographic pressure forced to increase the agricultural land and settled area 128.36 percent and 180.95 percent respectively from 1972-2016 periods. One most highlighted fact is an excessive growth of rubber plantation, which was totally absent during 1975 but in 2016 it occupied 20.64 percentage of the basin. Although present research has only identified the anthropogenic activities for such land use/land cover modifications but there are some other natural factors, such as, decreasing rainfall, increasing range of maximum and minimum temperature etc, responsible for such land use/land cover changes.

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